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Health and Nutrition Effects of Sugar Cane Production in South-Western Countries

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ABSTRACT
In 1984, a two-part study was initiated to evaluate the income and nutritional effects of shifting from maize to sugar cane production in south Nyanza, Kenya. During the first phase, baseline data was collected on the socioeconomic, food-consumption, and health and nutritional status of a cohort of households prior to their entry into the small-holder sugar cane out-growers scheme. The combination of the two studies provided one of the few opportunities to have baseline economic and health information on the households prior to their entry into cash cropping. In the first phase, the per capita income of the two groups was the same. In the follow-up of the cohort sample, the per capita income of the new entrant group was higher than that of the non-sugar group. This increase in income did not appear to influence pre-scholars' morbidity or growth. Data from both phases of the study indicate that the health and sanitation environment had the most impact on pre-scholars' growth, suggesting that growth will not be substantially improved in the short term by income alone.

INTRODUCTION
The commercialization of agriculture is the cornerstone of economic development in many developing countries. Proponents of strategies advocating an emphasis on commercial crops (often called cash crops) see this as a means of generating and saving foreign exchange, increasing the incomes of the rural small holder, providing employment for the landless and stimulating growth linkages with other segments of the economy.
Critics of the acceleration of the production of export and cash crops have argued that not only have the economic benefits not materialized, but in some cases the transition to commercial agriculture has had a negative effect on staple food production and hence household-level food security as well as health and nutritional status. Many of the most contentious nutrition issues in the debate have revolved around the impact of commercial agriculture on women and pre-scholars.
In 1984, at the request of the government of Kenya, a study was initiated to evaluate the income and nutritional effects of shifting from maize to sugar cane production. The government was concerned that in areas undergoing this transition, particularly the production of sugar cane, household-level food security and pre-scholars nutritional status were deteriorating.

Conceptual framework and research approach
Almost all of the previous research on the nutritional effects of cash crop production has concentrated on evaluating outcomes. Is cash cropping good or bad? This approach is simplistic, since presumably cash crops can have different impacts on income, consumption, and health. More important, the results of these types of studies-whether positive or negative-have limited usefulness for policy formulation. Emphasis exclusively on outcomes tells us nothing about the mechanisms through which commercial agriculture affects health and nutrition.
The 1984-1985 study was able to collect baseline data on the socio-economic, food-consumption, and health and nutritional status of a cohort of households prior to their entry into the small-holder sugar cane out grower's scheme. This group has been designated as the new entrants. They were followed until the time of payment for

the first harvest. Most prior research on the topic of commercialization of agriculture has involved ex-post studies only. Households were evaluated only after they had already entered a cash cropping scheme. Accordingly, it has been difficult to ascertain the baseline health and nutritional status of households and individuals prior to their making the transition. The combination of the two studies provided one of the few opportunities to have baseline economic and health information available prior to the entry of households into cash cropping.

Developed Country Experiences

Several studies on GM crop adoption in North America and elsewhere highlighted the multiple benefits derived from GM crops. Examples are the following:

United States

- An estimate cost savings by farmers planting HT soybean was $71.3/ha in 2012, almost three times higher compared to the early years of adoption. The annual total national farm income benefit from HT soybean has dramatically risen from $5 million in 1996, to nearly $6.07 billion in 2012.
- Glyphosate- and glufosinate-resistant corn reduced the herbicide use in corn production by 18.5 million pounds (15.2 and 3.3 million pounds, respectively) in 2004. US farmers saved $139 million from the reduced pesticide use.
- The US is estimated to have enhanced farm income from biotech crops by $53.1 billion in the period 1996 to 2012.

Canada

- HT canola has boosted the total canola production in Canada by 11% in 2012. Adopters of biotech canola earned $446 million in 2012.
- The net increase in farm income by HT maize farmers in 2012 was $12.2 million.
- Canada is estimated to have enhanced farm income from biotech crops by $4.9 billion in the period 1996 to 2012.

Spain

- BT maize adoption in Spain in 2012 resulted in yield increases of 6.3% on average, the net impact on gross margin $320.3 per hectare. Farmers also experienced savings on pesticide use by $8.24ha

Australia

- For 2012, Australian farmers planting IR cotton have significant cost savings of about $186-270/ha despite the high cost of technology. In 2012, net farm income at the national level was $766 million.

Developing Country Experiences

Bt cotton adoption in India

Cotton is a very important crop for India, accounting for 30% of its agricultural GDP. However, due to the high incidence of pests, especially the cotton bollworms, India falls short of the world's average yield of cotton by 48%, an equivalent of 280 kg/ha[2]. Indian farmers often lose up to 50-60% of their crop to the cotton bollworm. With the commercialization of Bt cotton in India in 2002, the cyclic infestation of bollworm has been suppressed.

In 2013, India ranks first in biotech cotton production worldwide, which produced 10.8 million hectares, followed by China (4.2 million hectares), USA (3.7 million hectares), and Pakistan (2.8 million hectares)9. Adoption of Bt cotton started in 2002 with 3 hybrids planted in six Indian states: Andhra Pradesh, Gujarat, Madhya Pradesh, Karnataka, Maharashtra and Tamil Nadu.[2] By 2013, there were 1,097 Bt cotton hybrids

approved for planting and a total of 10.8 million hectares of Bt cotton plantations in India. Fourteen studies on the impact of Bt cotton were conducted from 1998 to 2013. The results showed that yield increased by about 31 percent and insecticide spraying reduced by 39 percent, which translate to 88 percent increase in profitability (US$250/ha).

Qaim and Khouser (2013) conducted a study involving 1,431 farm households in India from 2002 to 2008 to investigate the effect of Bt cotton on farmers' family income and food security. According to the findings, the adoption of Bt cotton has significantly improved calorie consumption and dietary quality, leading to increased family income. The technology reduced food insecurity by 15-20% among cotton-producing households.

Table 1

Year	Total cotton area (Mha)	Hectarage (Million Has.)
2002-03	7.7	0.05
2003-04	7.6	0.1
2004-05	8.9	0.5
2005-06	8.9	1.3
2006-07	9.2	3.8
2007-08	9.4	6.2
2008-09	9.4	7.6
2009-10	10.3	8.4
2010-11	11.0	9.4
2011-12	12.2	10.6
2012-13	11.6	10.8
Source: ISAAA		

BT Corn Adoption in the Philippines

A common corn pest in the Philippines is the Asiatic corn borer which causes losses of up to 80% of production. Across the country, corn yield levels averaged only 2.8 tons per hectare. The Philippine government approval of the commercial release of BT corn marked the first time that a GM food/feed crop was ever approved for planting in Asia. Initial plantings of BT corn for the first year commercialization (2003) covered more than 10,000 hectares. Together with other biotech corn varieties (herbicide tolerant and Bt-HT), the total hectare in the wet and dry seasons in 2013 was 795,000 hectares, up from 750,000 hectares in 2012.

Bt rice in China

Rice is the most important crop in China, with the highest level of production accounting for 28% of the world's total production. Because of the importance of rice, biotech research is being conducted to combat insect pests in rice. It was estimated that the decrease in rice yield due to insect damage is estimated to cost at least several billions of dollars worldwide.

In China, insect-resistant GM rice has been approved for food, feed, and cultivation in 2009. To establish whether farmer's welfare improved by planting GM rice, farm surveys of randomly selected farm household that cultivated the biotech crop were conducted. The surveys showed that small and poor farm households who adopted GM insect-resistant rice benefited by having higher crop yields and lower pesticide usage compared to non-GM adopters. GM rice yields were 6 to 9% higher compared to conventional varieties and it required less pesticide input by as much as 80% or 16.77 kg/ha, which contributed to improved health to farmers.

High-valued cash crops represent one potential avenue of crop intensification. But the case for cash cropping has generally been based on the direct contribution that these crops have on farm incomes. A relatively

Neglected avenue of research concerns the effects that cash cropping can have on the productivity of other household activities, including food crop cultivation. This paper examines two potential pathways by which cash cropping may affect the productivity of other crops: (1) household-level synergies (which occur when the household's participation in a commercialized crop scheme enables it to acquire resources not otherwise available for use on other enterprises in the crop mix); and (2) regional spillover effects (which occur when a commercialization scheme may attract certain kinds of investments to a region which create spillover benefits to farmers engaged in other crops). Examples of these household-level and regional-level spillover effects include:

- Under credit and input market failures, commercialization schemes may be one of the few feasible ways to acquire credit and inputs. In some cases, through interlinked transactions for inputs, credit, management, and sale of product, the institutional mechanisms between farmers and marketing firms can relieve some of the market failure problems that constrain input intensification on grain crops. The success and sustainability of this pathway may depend on the firm's ability to recover its credit and associated costs of supporting smallholder production.
- Input-intensive cash crops, by promoting market demand for inputs, may induce private sector investment that improves the availability (and reduces per unit costs) of key inputs that can be used on a wide range of crops.
- The promotion of high-value, high-return enterprises may improve households' ability to invest in lumpy assets such as animal traction.
- Commercialization may support private investment in infrastructure and human capital that has broader benefits for other economic activities such as food crop production.

These potential synergies between cash crops and food crops have been generally neglected in food crop research and extension programs, although they may have important implications for programs designed to promote smallholder food crop productivity growth. More comprehensive information on the interactions between food and cash crop production may help in understanding the indirect payoffs to cash crop research programs and in refining extension strategies designed to promote food crop as well as cash crop productivity.

RESULTS

Income and food consumption

Proponents of a strategy advocating the commercialization of agriculture have assumed that farmers' incomes would increase as they switched all or part of their land to cash crop production. While higher income is only one of a series of household objectives, it is clearly an important one.

The income of the new entrant group (1,956 shillings per capita) was virtually identical to that of the non-sugar cane producers (KSh 1,924 per capita) in the 1984-1985 study. It is noteworthy, therefore, that in the follow-up study, the incomes per capita (both nominal and real) of the same new entrant group were significantly higher than those of the non-sugar group. In the follow-up study, both the new entrants and the sugar farmers had per capita incomes that were significantly higher than the non-sugar cane producers.

Part of this difference in incomes was due to differences in marketed agricultural income, KSh 791 and KSh 365 respectively. Other sources of income also contributed to the difference. Of the KSh 1,129 difference in nominal income per capita between the new entrants and the non-sugar cohort, 41% was contributed by commercial agricultural income, 38"/o by semi-subsistence income, and the remaining 21% by higher non-farm incomes in the new entrant group.

Interestingly, different sources of income have different effects on household energy intake, and these effects are above and beyond the pure income effect. The percentage of non-farm income has a significant and negative effect on caloric consumption. In addition, there is a beneficial effect from having income from production used for home consumption. This favors the non-sugar farmers, of whose income 49% comes from semi-subsistence production.

One major reason for the different effects of various sources of income on energy consumption may relate to control of income within the household. Non-farm income is earned and controlled primarily by men. Much of the aicultural production used for home consumption comes from female-controlled plots of land, and is more likely than male-controlled income to contribute to household energy. Female-controlled income and income from agricultural production are more likely than other forms of income to be used to enhance household food security. The data from the present study also suggest that semi-subsistence income has more of a positive effect on energy intake than other forms of income. It may be that, in addition to the issue of control of income (male versus female), the real or perceived transaction costs of converting food crop income into cash may make it more likely that semi subsistence production contributes to household food security.
Energy consumption has a negative and significant association with years of schooling of the head of household. Males who are more educated are generally wealthier in this community, as is typical in most countries. It appears that increased wealth is related to a more varied diet rather than simply a more energy-dense diet. Similar results are seen when total expenditures are used as a proxy for income.

Morbidity patterns of pre-scholars

The sugar cane scheme is one form of development assistance that was directed towards the south Nyanza district with the expectation that the economic growth generated by the out growers' programme would result in an improved health and nutritional status for the population, and in particular for the vulnerable groups-pre-school-age children and pregnant and lactating women. The study allows us to assess whether income changes in the longer term are associated with decreases in morbidity.
Table 3 presents data on morbidity patterns for women and pre-scholars for all four rounds combined. For the cohort sample, there was no significant difference in the total time ill or the time ill with diarrhea for pre-scholars across any of the activity groups. The significant gains in income for the new entrant group have not translated into a decrease in the average time ill for pre-scholars.

TABLE 2
Time ill and time ill with diarrhea for preschoolers and women, cohort sample

	Pre-scholars		Women
	Total time ill (%)	**Time ill with diarrhoea (%)**	**Total time ill (%)**
New entrant	29.5 (85)	4.7	24.5 (32)
Sugar	29.8 (428)	4.6	23.8 (168)
Non-sugar	31.2 (542)	4.0	24.3 (220)
Merchant	20.8 (45)	2.0	21.8 (16)
Wage earner	31.6 (30)	4.5	31.9 (14)
Landless	31.6 (62)	3.8	21.8 (31)
Sample X	30.3 (1,192)	4.2	24.1 (481)

Source: Ref. 2.
Based on average of all rounds.
No two groups significantly different.
Numbers in parentheses equal number of women or children.

Morbidity patterns for women and pre-scholars were analyzed within per capita quartiles. For both groups, there were no significant differences across income quartiles in the total percentage of time ill. There also were no differences for pre-scholars across income quartiles in the total time ill with diarrhea.

Nutritional status of pro-scholars

The present research was conducted in an area of Kenya with the highest mortality rate from birth to age two years-216 per 1,000-of any part of the country. The area also has a high prevalence of pre-scholar malnutrition. The government hopes that one positive effect of the transition from semi subsistence to commercial agriculture will be improvements in general well-being, including in child health and mortality rates.

TABLE 3

Z scores for children in studies 1 and 2

	Study 1 Z score			Study 2 Z score (all-round average)		
	Height/age	**Weight/age**	**Weight/height**	**Height/age**	**Weight/age**	**Weight/height**
New entrants	- 1.46 (90)	- 1.13 (90)	-0.27 (90)	- 1.74 (61)	- 1.06 (61)	0.005 (61)
Sugar farmers	- 1.34 (356)	- 1.03 (356)	-0.22 (356)	- 1.67 (243)	- 1.14 (243)	-0.15 (241)
Non-sugar farmers	- 1.50 (556)	- 1.17 (556)	-0.31 (556)	- 1.76 (349)	- 1.10 (353)	-0.04 (349)
Merchants	- 0.99 (62)	- 0.86 (62)	- 0.27 (62)	- 1.05 (29)	- 0.89 (29)	- 0.26 (29)
Wage earners	- 1.65 (30)	- 1.49 (30)	-0.59 (30)	- 1.87 (24)	- 1.49 (24)	- 0.51 (24)
Landless	- 1.45 (77)	- 1.06 (77)	-0.18 (77)	- 1.99 (40)	- 1.36 (40)	-0.16 (39)
Sample mean	- 1.42 (1,171)	- 1 11 (1,171)	-0.28 (1,171)	- 1.72 (746)	- 1.13 (749)	-0.10 (743)

No two groups significantly different.
Numbers in parentheses equal number of subjects

The Z scores for height for age, weight for age, and weight for height averaged for all four rounds for studies. These data are on the cohort of children who were in both studies. This sample was therefore older in study 2. In the 19841985 study, there were no significant differences in any of the three anthropometric indicators across any of the three groups. This was somewhat surprising, given that in study 1 the incomes of the sugar farmers were approximately 25% higher than those of the non sugar farmers and new entrant groups. In the later study, however, the same results emerged; no significant differences were found across any of the households in any of the three indicators, despite the fact that the new entrants had an average income per capita that was significantly higher than the non-sugar group.

COMMENTS

The present study is one of the few based on a random sample of farmers in a commercial out growers' scheme. In addition, it is one of the few studies to date that provides a community assessment of the range of effects of commercial agriculture. One premise was that some of the most dramatic effects of cash cropping might be on households not directly involved in the scheme-the landless and the merchants.

The study design was methodologically much stronger than is usual for research of this type; the new entrant group on whom baseline information was available prior to their entry into the sugar cane out growers' scheme could be followed until the time of first harvest. This allowed stronger inferences to be made about the actual impact of commercial agriculture.

The results suggest some positive effects of commercial agriculture on household income. In the 1984-1985 study, the incomes per capita of the two groups were virtually identical. In the follow-up of the cohort sample,

the income per capita of the new entrant group was KSh 1,129 higher than the non-sugar group. Part of this increment was due to differences in commercial agriculture income. The new entrants earned KSh 791 per capita from commercial agriculture compared to KSh 365 per capita for the non-sugar producers. Here again, in 1984, the commercial agriculture income per capita of the new entrants (KSh 404) and the non-sugar farmers (KSh 393) was almost identical. Entry into sugar cane production thus increased incomes.

The sugar cane out growers' programme as it is implemented in Kenya was associated with a significant increment in income. This resulted in positive effects on the household energy consumption of the new entrant group. This benefit, however, did not appear to have influenced pre-scholars' morbidity or growth. There is a growing awareness that family-level factors may be poor indicators of a child's nutritional status.
Many governments and international agencies are putting increased emphasis on income-generating schemes as a way of achieving health and nutrition objectives. While increases in income may be a necessary condition, by themselves they may not be sufficient to alleviate malnutrition, at least in the short term.

Data from both studies suggest that it was the health and sanitation environment that had the most impact on preschoolers' growth. One of the major determinants of child growth was the growth pattern, which was influenced significantly by pre-schoolers' morbidity patterns and the health and sanitation environment. Children who were not doing well earlier continued to record inadequate growth. This suggests that without improvements in factors that influence their health, pre-schoolers' growth will not be substantially improved in the short term by income alone. More emphasis must be placed on the health implications of agricultural policies and projects, with particular attention paid to ways to improve the health infrastructure in a given community.
The insignificant effect of income on health may relate to whom within the household controls it. Sugar income is not seen as household income but rather as men's income. Not only is men's income different from women's but the expenditure responsibilities differing. It is therefore not surprising that the money earned from sugar production is spent on items like housing and school fees, categories of non-food expenditures that fall within the responsibility of men.

TABLE 4
Decision-making for food expenditures and sugar cane income

Decision-maker	**Households (%)**
For food expenditures	
Husband	15.5
wife/wives	76.3
Joint	5.9
other household members	2.3
For sugar cane income	
Husband	79.0
wife/wives	5.5
Joint	12.8
other household members	2.3
do not know	0.5

Part of the difference in expenditures for men and women may also relate to the periodicity of income. Women's income in the form of food crops and trading activities comes in smaller, more continual amounts. This may influence how the money is spent. Men's income from sugar comes only after 18 to 24 months of work and is paid in one lump sum. Income from lump sums tends to be spent differently than that from small, regular sources.

Income is influenced by control (male versus female) and its pattern of flow into the household. If policymakers are interested in maximizing the nutritional effect of increased income, several steps might be taken. First, if it is culturally appropriate, the contract for the cash crop-in this case, sugar cane- should be in the name of both the head of the household and the wife (wives). This would help foster the perception of household income rather than simply male income.

Second, more periodic payment for the sugar cane crop-advances against anticipated production- might ensure that the marginal propensity to spend on food and other nurturing categories would be higher than it is with lump sums.

Finally, one issue that was not touched upon directly in the study warrants discussion. The community in which the out growers' scheme was implemented is one where malnutrition is endemic. Households may not be aware of the problem since their children look like all the others in the community. The out growers' programme involves approximately 30% of the households in the community and would be an excellent and visible way to reach a significant portion of the population regarding the nutritional needs of women and children. Nutrition education integrated into a primary health care delivery system could have a significant effect on the health and sanitary environment of children. To date, most of the farmers who have joined the out growers' scheme have remained in it. It is naive to think that, given the way the programme now operates, there will be a mass exodus back to food crop production. Some fine tuning of the programme will help maximize the potential impact of the increased income on household and preschoolers' nutritional status.

FINDINGS: The principal findings of the paper are:

The increasing number of farmers who have grown GM crops both in the developed and developing countries is strong evidence of their advantages in agricultural production and value to farmers. In 2013, after 18 years of GM crop adoption, an accumulated hectare of more than 1.5 billion hectares, were planted by 18 million farmers. This unprecedented high adoption rate reflects the trust and confidence of millions of farmers in crop biotechnology. Experiences of small farmers from China, South Africa, the Philippines and other developing countries using GM crops clearly show that small farmers can also benefit from the technology. The most consistent observation from these countries is that growing GM crops is a profitable farming endeavor.

This area of Developing Countries is highly commercialized in cotton production. Maize accounts for 47.4% of cropped area, while cotton accounted for 45.2%. However, there are clear differences in the purposes for growing these crops: 100% of the cotton production was marketed, while 93.8% of maize production was grown for home consumption. Cotton sales contributed 83.6% of the value of marketed crop income. Especially under conditions of credit and input rental market failures, cash cropping schemes may enable households to increase both input use and productivity of food crops. Also gross crop income per hectare and per family member was positively related to the share of cotton in cropped cultivation.

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